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HI Absorption Observations of two Radio Sources near the Supernova Remnant G 127.1 + 0.5

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Abstract. The compact source 0125 + 628 in the centre of the galactic supernova remnant G 127.1+ 0.5 has been re-observed in HI absorption using the Westerbork Synthesis Radio Telescope (WSRT). The outer arm HI absorption at V= –95km s^{-1} has been confirmed. The absorption spectrum is similar to that of the nearby extragalactic source 0123 + 633. We discuss the arguments concerning an extragalactic origin of 0125 + 628 and conclude that it is most likely extragalactic and not an SS 433 type object.

Key words: HI absorption—galactic supernova remnants

1. Introduction

The nature of the compact nonthermal source in the centre of the galactic supernova remnant (SNR) Gl27.1 +0.5 has remained controversial. The debate has been whether the source is galactic and associated with the SNR or whether it is an extragalactic object. Arguments in favour of a galactic origin are:

(1) It is located almost precisely at the centre of the SNR (Caswell 1977).

(2) The source shows VLBI structure, in contrast to a nearby source (displaced by 8°) which is dominated by the effects of interstellar scattering (Geldzahler & Shaffer 1982; hereinafter GS).

(3) The SNR has morphological features which align with the Very Long Baseline Interferometry (VLBI) (core-dual-jet) structure (GS).

Arguments in favour of an extragalactic origin are:

(1) The optical spectrum is similar to that of a radio galaxy with a redshift of ~ 0.02 (Kirshner & Chevalier 1978; Spinrad, Stauffer & Harlan 1979).

(2) The HI absorption spectrum places it behind essentially all the galactic hydrogen at this longitude (Pauls *et, al.* 1982).

If 0125 + 628 is in fact galactic and associated with the SNR, it would be classified as an SS 433 type object and thus be quite rare. Thus a classification of the object is

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important. An ideal observational test would be a direct comparison of the HI absorption towards the point source and the SNR. The latter observation is, however, very difficult due to the extremely low surface brightness of the SNR at 21 cm. We have thus decided to follow the same method that was used for SS 433 (van Gorkom *et al.* 1982) and compare the HI absorption spectrum of 0125 + 628 with that of a nearby point source (0123 + 633), which is almost certainly extragalactic. This test only provides information about the distance of 0125 + 628 and provides no direct evidence concerning the distance of the SNR.

In this paper we present new HI absorption observations in the directions of 0125 +628 and 0123 + 633. The previous HI data (Pauls *et al.* 1982) had poor signal-to-noise ratio at the more extreme velocities ($V < -90 \mathrm{kms}^{-1}$) arising from the outer arm of the Galaxy. It is precisely these velocities which are crucial for any distinction between a galactic and an extragalactic source. The new data have a factor of three improvement in sensitivity. The previous results are confirmed, thus supporting an extragalactic origin of 0125 + 628. This led us to re-examine the arguments for and against a galactic origin of the object; contrary to GS we conclude that an extragalactic origin is more likely.

2. Observations

The 21cm HI observations were carried out in the autumn of 1982 using the Westerbork Synthesis Radio Telescope (WSRT). The observing procedure is similar to that described by Pauls *et al.* (1982) and van Gorkom *et al.* (1982). The 10 fixed telescopes were correlated with the more distant movable telescopes C and D. The spacings range from 1368 m to 2736 m for 0125+628 and 1350 to 2718 m for 0123 + 633 at intervals of 72 m. (The spacings below ~ 1300 m were not observed in order to avoid the effects of HI emission.)

Both 0123 + 633 and 0125 + 628 were observed for 12 hours with orthogonal linear polarizations. The total bandwidth was 0.625 MHz with 63 frequency channels and a velocity resolution of 2.5km s^{-1}. The rms noise in a single channel is 7mJy as compared to 21 mJy in the earlier observations reported by Pauls *et al.* The flux density of 0125 + 628 was 400 mJy in close agreement with the value measured by Pauls *et al.* (1982) in 1979. The source 48 W8 (Pauls *et al.*) or 0123 + 633 has a 21 cm flux density of 210mJy. The position at 21cm is $\alpha(1950) = 0.1^{h}23^{m}18^{s}.29 \pm 0^{s}.06$, $\delta(1950) = 63°19'54''.5 \pm 0''4$ [The position quoted by Caswell (1977) differs by 1.5arcmin.]

3. Results

In Fig. 1 we show the WSRT HI spectra of 0123 + 633 and 0125 + 628. Because of the choice of the central velocity of -60 kms^{-1} the strong absorption near 0 km s^{-1} (Pauls *et al.* 1982) is not fully covered. The spectrum of 0125 + 628 is in good agreement with the earlier WSRT data and the prominent line at -95 km s^{-1} ($\tau \sim 0.1$) is confirmed. The absorption spectrum of 0123 + 633 (which is 0°.5 displaced on the sky) is quite similar in form to 0125 + 628. In particular there are prominent lines at $V = -70$ kms^{-1} and $-97 \mathrm{kms}^{-1}$ ($\tau \sim 0.2$). The HI emission spectrum in this direction (Pauls *et al.* 1982) shows prominent lines up to a velocity of —100 km s^{-1}.

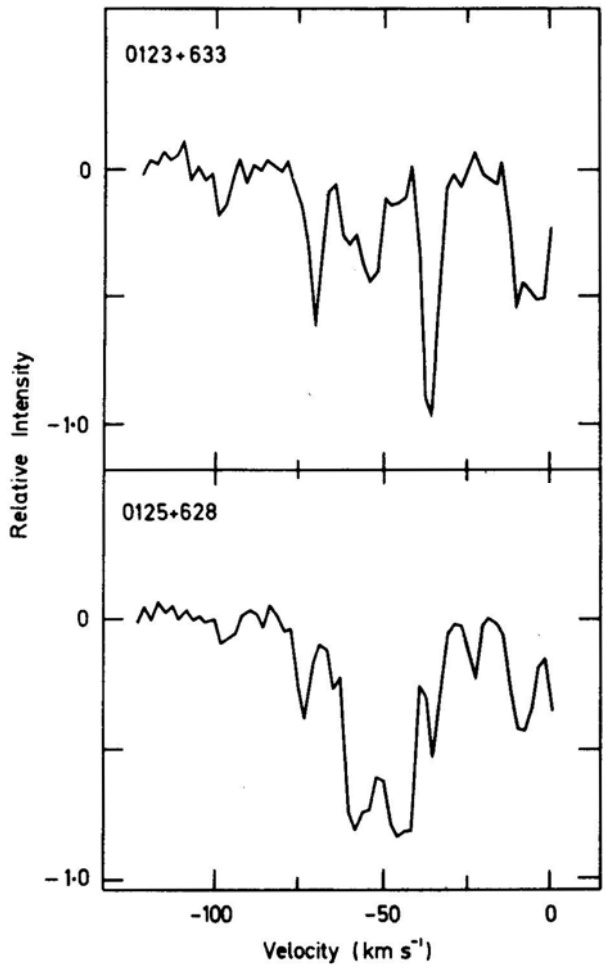

Figure 1. HI absorption spectra of 0123 + 633 (above) and 0125 + 628 (below) obtained with the WSRT. Velocity is with respect to the local standard of rest. The velocity resolution is 2.5 km s^{-1}.The intensity scale is relative intensity (–1 is complete absorption and 0 is no absorption). The flux densities of 0123 + 633 and 0125 + 628 are 210 and 400 mJy, respectively.

4. Discussion

The HI absorption data show that both 0125 + 628 and 0123 + 633 are behind essentially all the galactic HI in this direction. This provides a lower limit of 8 kpc to the distance. The comparison point source (< 10 arcsec in size) 0123 + 633 is probably an extragalactic source observed in projection near the SNR G 127.1 + 0.5. The spectral index between 49 and 21 cm is –0.33 ($S \propto \nu^{\alpha}$). The similarity in HI spectra between this source and 0125 + 628 suggests that 0125 + 628 is also probably extragalactic. The present result removes one of the stronger arguments of GS indicating that 0125 + 628 is galactic. GS also make a comparison with a nearby source 0241 + 622, which is 8° away. They find the structure on VLBI size scales for 0125 + 628 while the size of 0241 + 622 is dominated by the effects of scattering. GS conclude that either the path

length to 0125 + 628 through the galaxy must be substantially less than toward 0241 + 622, or there is a 'hole' in the interstellar scattering medium. The HI data show that the latter explanation must be correct, since the path length is at least 8 kpc. 'Holes' in the interstellar scattering medium have been found to be quite common in the galactic anti-centre direction (Dennison *et al.* 1984) as determined by low-frequency VLBI studies of measured angular sizes of background sources.

The possibility does remain that both 0125 + 628 and the SNR are at a distance of 8 kpc, although the surface-brightness diameter (Σ–D) relation (Mills *et al.* 1984) indicates a distance of 4 kpc for the SNR. However, if there is an internal energy source in the SNR the conventional Σ–D relation may not be valid. Although this possibility cannot be ruled out, there does seem to be compelling evidence that 0125 + 628 is not an SS 433 type object. The most important differences are:

(1) SS 433 has a stellar appearance in the optical and (2) has a composite spectrum consisting of a narrow emission-line system at rest superimposed on the broad-line fast-moving system (Margon *et al.* 1979). 0125 + 625 on the other hand has (1) a diffuse optical appearance and (2) the emission lines resemble a radio galaxy with a constant redshift of ~ 0.02 (Kirshner & Chevalier 1978; Spinrad *et al.* 1979). The SNR W 50 has enhanced bright regions ('ears') that are aligned with the jets from SS 433. G 127.1 + 0.5 is spherical with numerous hot spots and breaks in the shell. As reference to the map published by Salter, Pauls & Haslam (1978) indicates, there are many orientations in the SNR which would lead to alignment with the VLBI structure of 0125 + 638.

In summary, although SS 433 and 0125 + 628 do have many similarities in their radio properties, the current evidence suggests that the latter source is extragalactic.

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